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Preliminary study: human trampling effects on seagrass density

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Abstract. This preliminary study performed a small-scale experimental evaluation of the effects of trampling on tropical seagrass meadows. The study site was Barrang Lompo Island, in the Spermonde Archipelago, South Sulawesi, Indonesia. The experimental design comprised two trampling treatments (trampling by an adult and by children) and a control plot (no trampling). The trampling was carried out daily over a three week period. After trampling (adult or children), the detached seagrass leaf biomass was higher than uprooted seagrass biomass. Trampling by an adult had a greater effect on seagrass density than trampling by children. Three weeks after trampling ceased, both treatment plots exhibited substantial recovery, with final density closer to control density in the plot trampled by children.

1. Introduction

Seagrass meadows provide important ecosystem services, including habitat for diverse and often abundant fish and shellfish communities [1–4] as well as charismatic megafauna such as dugongs and sea turtles [5,6]. Despite growing awareness of their importance, degradation and loss of seagrass meadows is a worldwide phenomenon [7–10]. The annual global loss of known seagrass areas was recently estimated at 7%/year [11], while the main cause of seagrass degradation is anthropogenic disturbance [8,12,13].

Fishery-related activities have been linked to decreases in temperate seagrass cover, mainly in shallow estuarine and tidal waters [14–17]. Trampling by humans during certain fisheries activities is also thought to have negative effects on seagrass meadows [18,19].

Trampling by local community members (either children or adults) is common in many populated tropical small islands, including in Indonesia. Trampling may occur when gleaning at low tide [20], or when people go to catch fish within seagrass meadows, especially when setting and operating gill nets (Pers. Obs.).

This raises the question: what is the impact of human trampling on seagrass meadows, especially with relation to seagrass density? Negative effects on seagrass density associated with trampling have been reported [18,19]. However, studies of trampling pressure on seagrass beds in general, and tropical seagrass meadows in particular, remain extremely limited. This preliminary study examined the effect of trampling by an adult and by children on seagrass density in a tropical seagrass meadow.

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2. Materials and Methods

The experimental site was situated in the intertidal zone, South East of Barrang Lompo Island (S 05˚03’099’’, E 119˚19’767’’) in the Spermonde Archipelago, South Sulawesi, Indonesia (Figure 1).

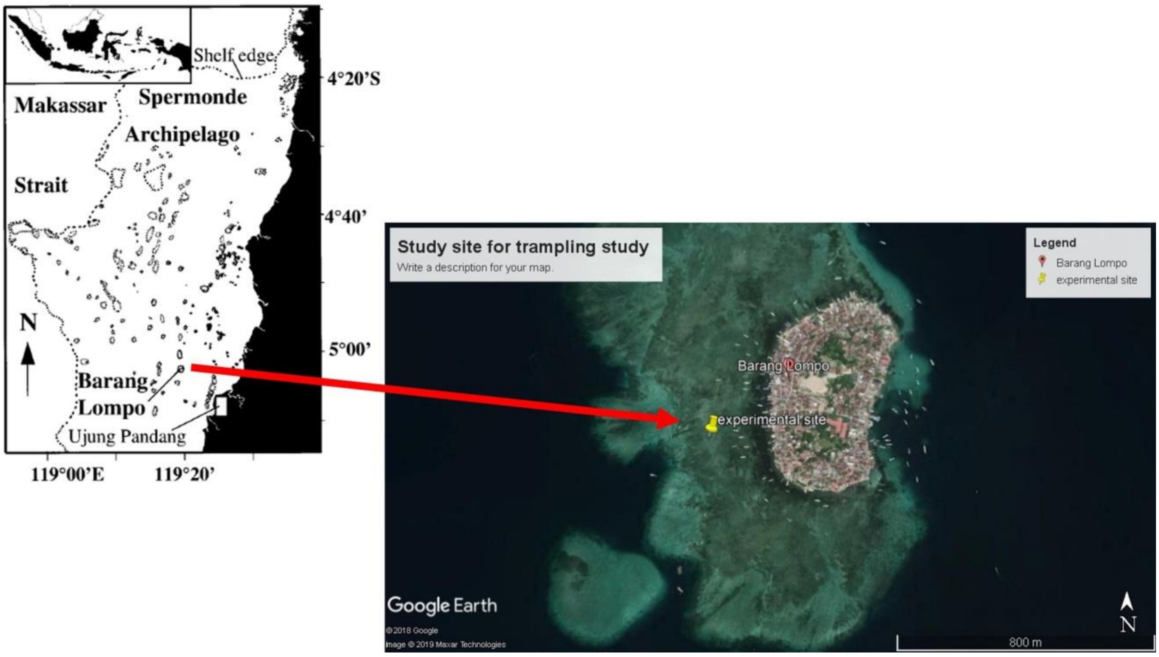

Figure 1. Map of study site. Left: map showing Barrang Lompo Island location within the Spermonde Archipelago (adapted from [21]); Right: satellite image (Google Earth) showing the experimental site in the seagrass meadows around Barrang Lompo Island (adapted from [22])

The experimental design consisted of three (5 m × 3.5 m) trampling paths (I = trampling by three children, II = trampling by an adult, and control = with no trampling). The paths were set up in line with the prevailing current direction, placed 3 m apart to minimize any interactive effects, and marked with wooden stakes. Path layout was based on [18] (Figure 2).

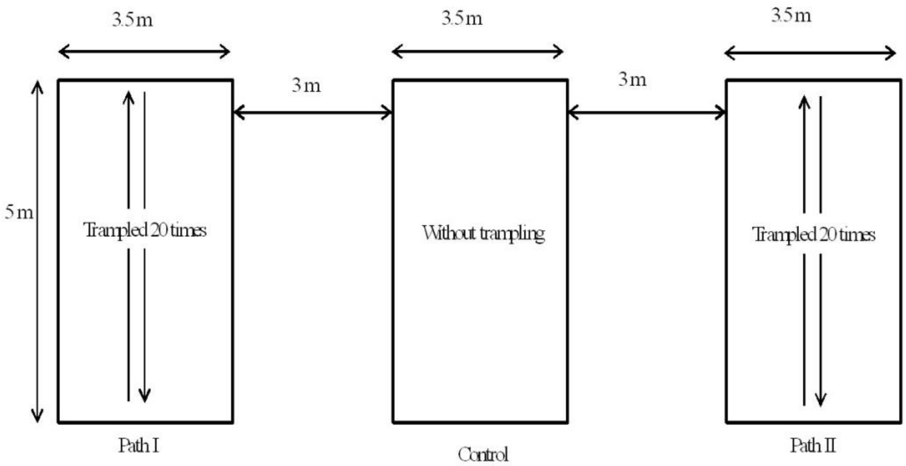

Figure 2. Trampling path layout applied during the experiment

Trampling took place during the first three weeks, followed by a recovery period of three weeks with no trampling. In path I, a 60 kg adult person wearing rubber boots, walked to the end of the path and back 20 times each day. In path II, three children (21, 31, and 36 kg) simultaneously walked up and down the path 20 times each day, wearing rubber thong sandals

Percentage seagrass cover (before the preliminary experiment) and seagrass density (during trampling and after trampling) was measured weekly following [23]. Detached leaves and uprooted seagrass plants were collected, dried (constant weight at temperature 70˚C), and the respective dry weights recorded. Environmental. Substrate type was also recorded. The data were tabulated and analysed descriptively through Microsoft Excel.

3. Results

The initial average (before the preliminary experiment) seagrass percentage cover within the experimental area was 55%, dominated by *Halodule uninervis* (around 90%) followed by *Thalassia hemprichii* (around 10%). The substrate was fine sand in and among paths. Damage to seagrasses (Figure 3) was observed in both the path trampled by adults and that trampled by children.

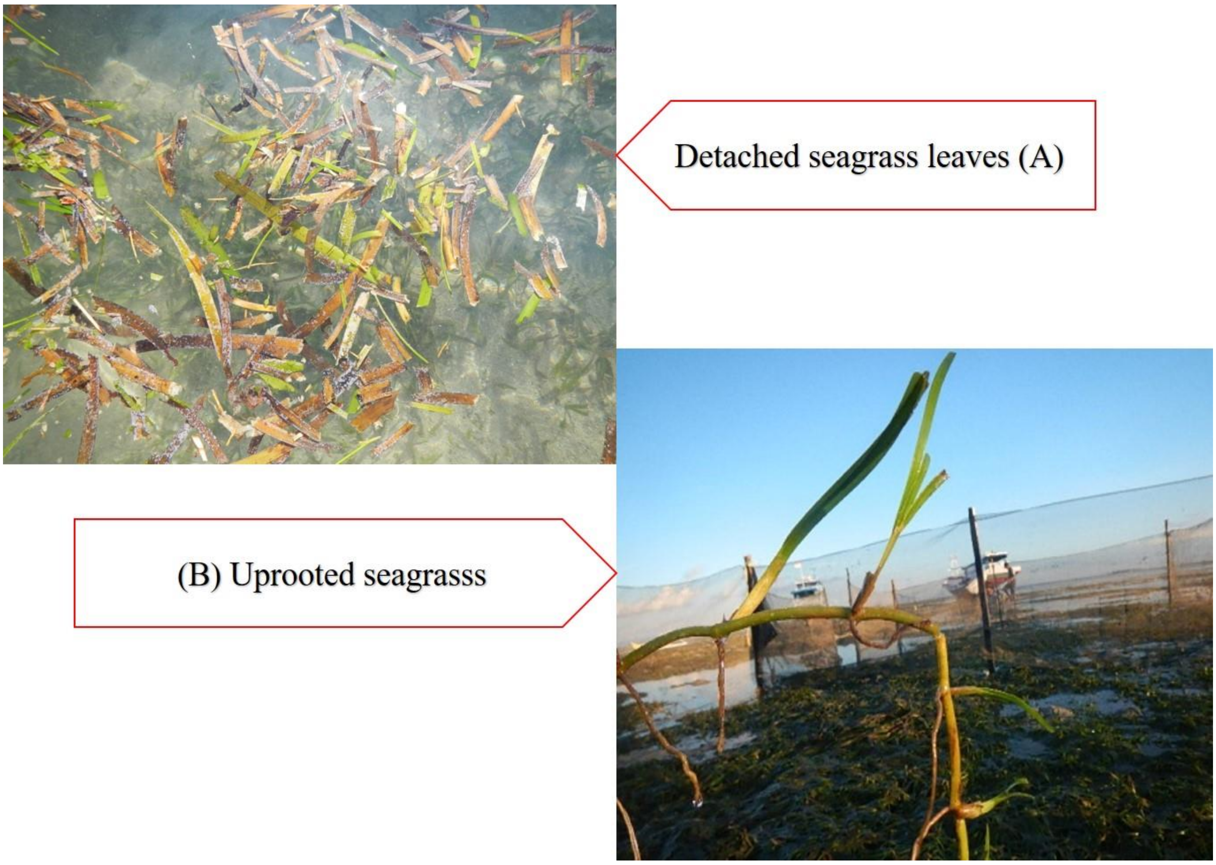

Figure 3. Examples of the damage to seagrass during the trampling experiment

Biomass measurements (Figure 4) confirm the visual impression that breaking off and detachment of seagrass leaves was the dominant form of physical damage, while relatively few seagrass plants (all *Thalassia hemprichii*) were uprooted.

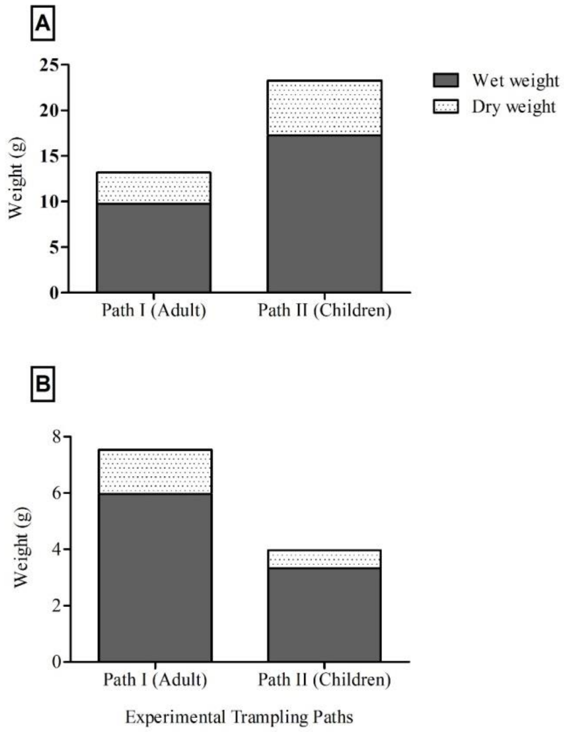

Figure 4. Observed damage to the trampled seagrass plots.
A. detached seagrass leaf biomass
B. uprooted seagrass biomass

Seagrass density in the two trampled paths (Figure 5) followed a similar pattern of decreasing density during the 3 trampling weeks, then increasing, albeit slowly at first, with substantial recovery observed in both trampling paths by week 3).

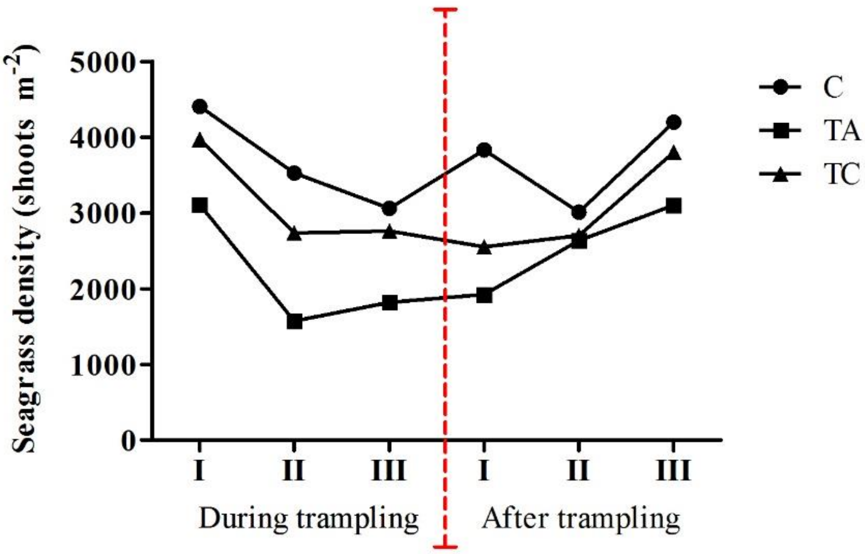

Figure 5. Observed seagrass density during the 3 weeks with daily trampling (during trampling) and during the 3 week recovery period (after trampling).

4. Discussion

The data indicate that trampling by children may cause less mechanical damage and have less impact on seagrass density than trampling by adults, even when children are more numerous (in this study, 3:1). This may be due to lower pressure exerted during children's trampling compared to the trampling pressure exerted by a (heavier) adult. Another factor might be speed of movement, and thus duration of pressure, as the children tended to walk faster than the adult, a trend commonly observed during normal community activities in seagrass beds. The difference in footwear (boots versus thong sandals) might also have contributed to the difference in damage severity.

A study in *Thalassia*-dominated meadows [18] found that seagrasses can recover naturally when pressure or disturbance is minimized or has ceased. Our results indicate that a faster recovery rate than that reported by [18] might be possible, i.e. on a scale of weeks rather than months. One factor could be the dominant genus at the study sites (*Halodule* rather than *Thalassia*). Leaf life span and rate of new leaf production can also affect the timeframe required for regeneration. Leaf longevity ranges of 20 – 40 days in *Halodule* sp. and 30 – 65 days in *Thalassia* sp. have been reported [24]. Shorter leaf longevity is reported for *Thalassia hemprichii* (24 to 40 days), with average leaf longevity varying seasonally from 28 to 33 days [25]. It is possible that *Halodule uninervis* may have faster natural regeneration rates than *Thalassia sp.,* in particular *T. testudinum* [18] and *T. hemprichii* (this study).

Differences between seagrass taxa in their intrinsic vulnerability to physical damage, both breaking off of leaves and uprooting of plants, may be a factor. In this study, only *T. hemprichii* plants were uprooted. Furthermore, (unquantified) visual examination of detached leaf biomass before drying indicated that *T. hemprichii* contributed considerably more than the 10% to be expected based on percentage cover. Leaf loss rate is important in internal nutrient cycles. Nutrients tend to be transferred to actively growing young leaves before the natural shedding of older leaves occurs, contributing up to 25% of nutrients required for seagrass growth [26]. This transfer process can reduce the annual requirement for nitrogen uptake by up to 25% [27]. Thus, premature shedding of older leaves could have a significant impact on seagrass growth, affecting primary production and thus total ecosystem productivity as well as the rate of recovery from stochastic or anthropogenic disturbance.

According to [25], the seagrass *T. hemprichii,* which has relatively thin leaves compared to some other seagrass species (e.g. *Enhalus acoroides*), is intrinsically sensitive to intensive solar radiation and intolerant to drying out. During low tide the leaves of *T. hemprichii* will dry when exposed to the sun, thus becoming more brittle and more easily broken by water movement such as waves and currents when the tide rises, resulting in leaf mortality and shedding [28]. In comparison, *Halodule uninervis* has smaller but proportionally thicker leaves, and seems less affected by solar insolation even at low spring tides. Observations during this study, including the relatively low proportion of detached leaves compared to percentage cover, indicate that natural leaf shedding rate may be lower. Furthermore, compared to most other tropical seagrasses, particularly high thermal tolerance and resistance to insolation have been reported for *Halodule uninervis* [29]. Thus seagrass species composition is likely an important factor with respect to the potential for damage from trampling. Furthermore, trampling could potentially affect seagrass meadow species composition, favouring "trampling-resistant" species over those more vulnerable to trampling damage.

5. Conclusion

This study found that human trampling, especially by adults, can reduce seagrasses density in tropical seagrass meadows. *Thalassia hemprichii* seemed more vulnerable to physical damage (leaf detachment and uprooting) than *Halodule uninervis*, indicating a need for further research into species-specific responses of seagrasses to anthropogenic stressors, including trampling, as well as the responses of various species combinations in mixed seagrass communities.

The substantial recovery observed after a relatively short time (three weeks) indicates that intermittent human activities which involve trampling in seagrass meadows could enable seagrasses to recover naturally between trampling events. The difference between trampling by an adult and children point to a need for further research into the effects of trampling on seagrass. In particular, the differential impacts of and recovery periods required after trampling by people of different ages and weights, carrying out various activities in seagrass meadows over different time-scales, in seagrass meadows with different characteristics, specifically seagrass community species composition.

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